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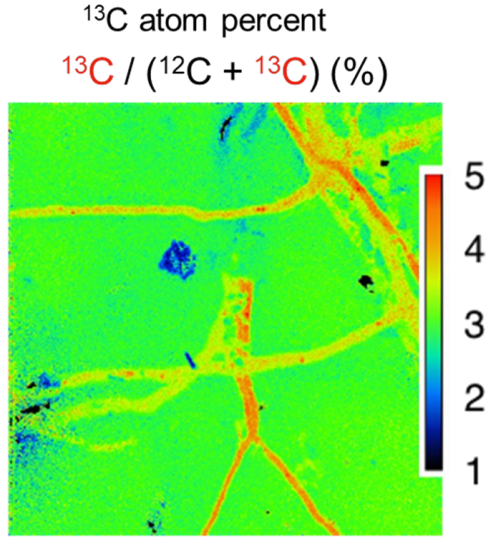
Design of biodegradable materials based on fundamental understanding of biodegradability and digital tools

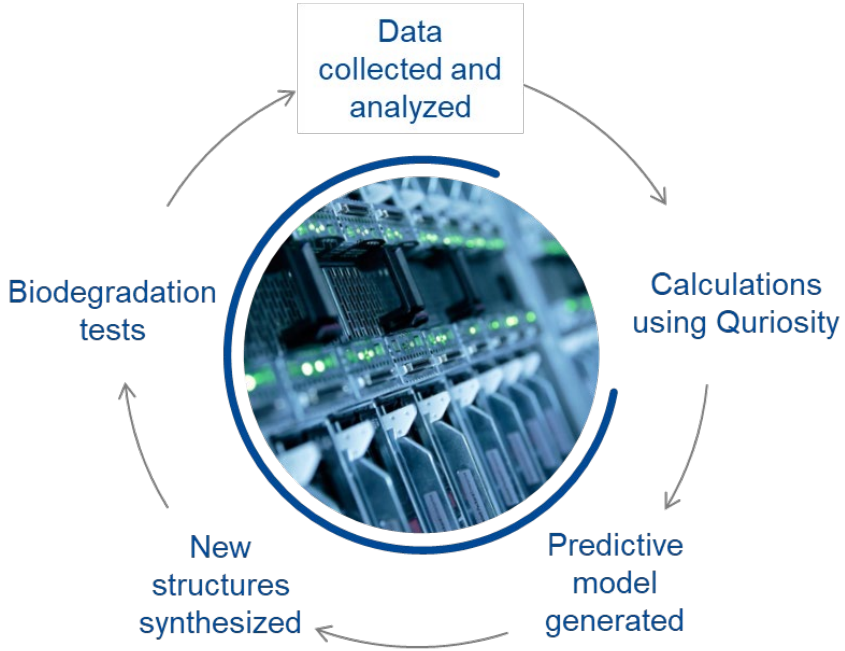
Andreas Künkel

Vice President, BASF SE

EUIndTech

Kraków, Poland, May 2025





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Agenda: “Design of biodegradable materials based on fundamental understanding of biodegradability and digital tools”

1 **Introduction**

2 Structural biodegradable polymers – soil

3 Digital tools

4 Conclusion

Biodegradability 2.0

Holistic approach for biodegradability with different technologies and partnerships

Lab test systems

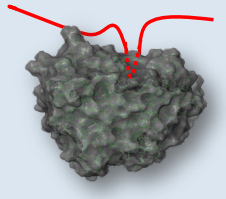
Correlation & reliability

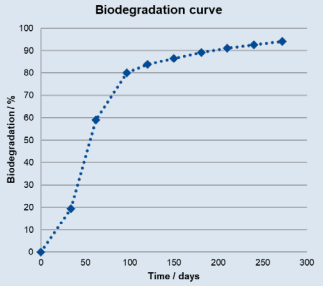
Mesocosm & field conditions

standard development and stakeholder dialogue

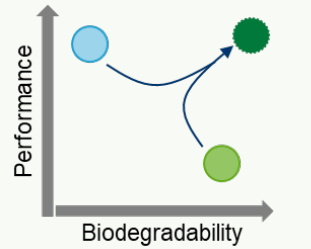
Cooperations academia & industry

Fundamental understanding of specific material biodegradation in target end of life environment





Data infrastructure and consistency, automation & predictive modelling



material development and formulation

Microbiology & enzymes

Biodegradation pathways / fate of material

Analytical tools for complete biodegradation assessment

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Certified soil-biodegradable ecovio® mulch film as contributor to sustainable agriculture

Dialogue, biodegradation standards and development of certified biodegradable products

ecovio® is the trade name for BASF's compounds based on ecoflex® and polylactic acid (PLA)

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ecovio® M2351 mulch – biodegradation in soil according to EN 17033

Biodegradation of ecovio® M2351 mulch film relative to cellulose control

At **181 days**, **89.1%** biodegradation, relative to cellulose was measured – absolute biodegradation of 94.4% (±1.7%).

Where is the rest?

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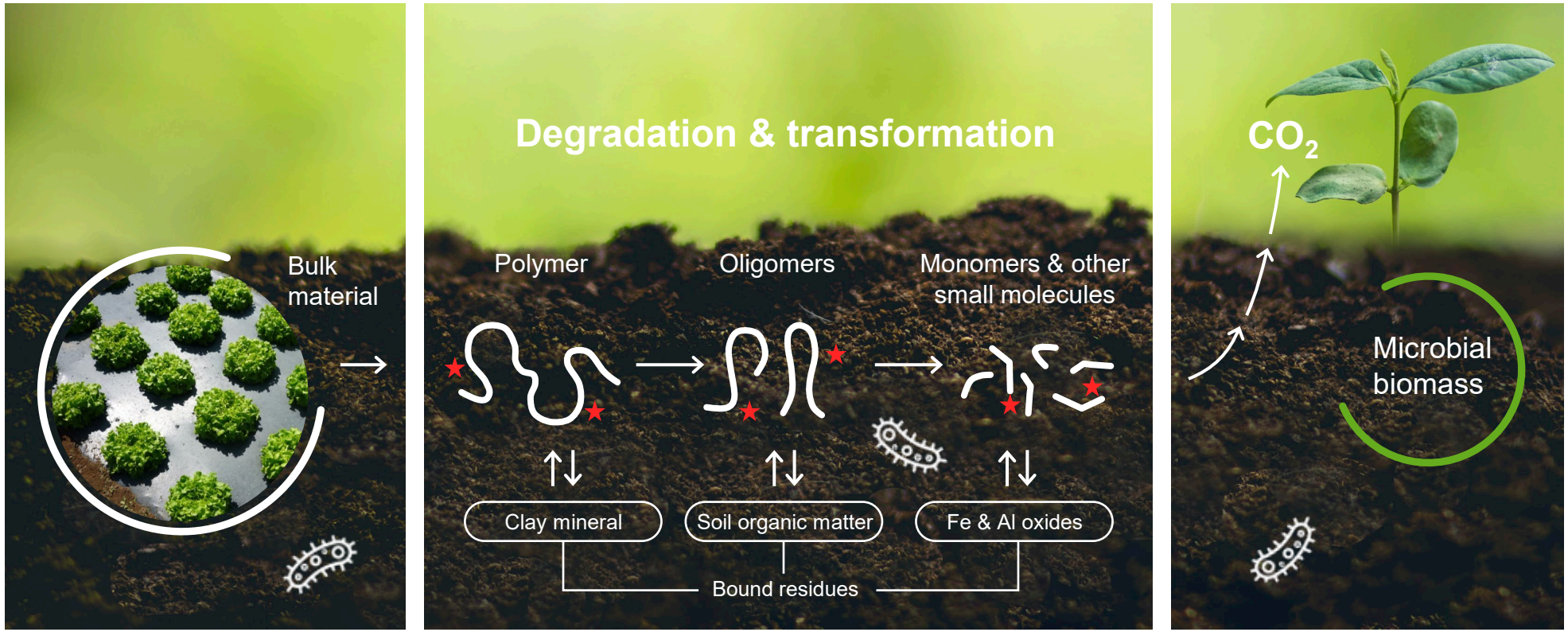
Decisive methods for understanding ecovio® mulch film's biodegradation in soil



★ Modified ^{13}C labeling of the monomers

Where does the polymer carbon end up?

ETH zürich

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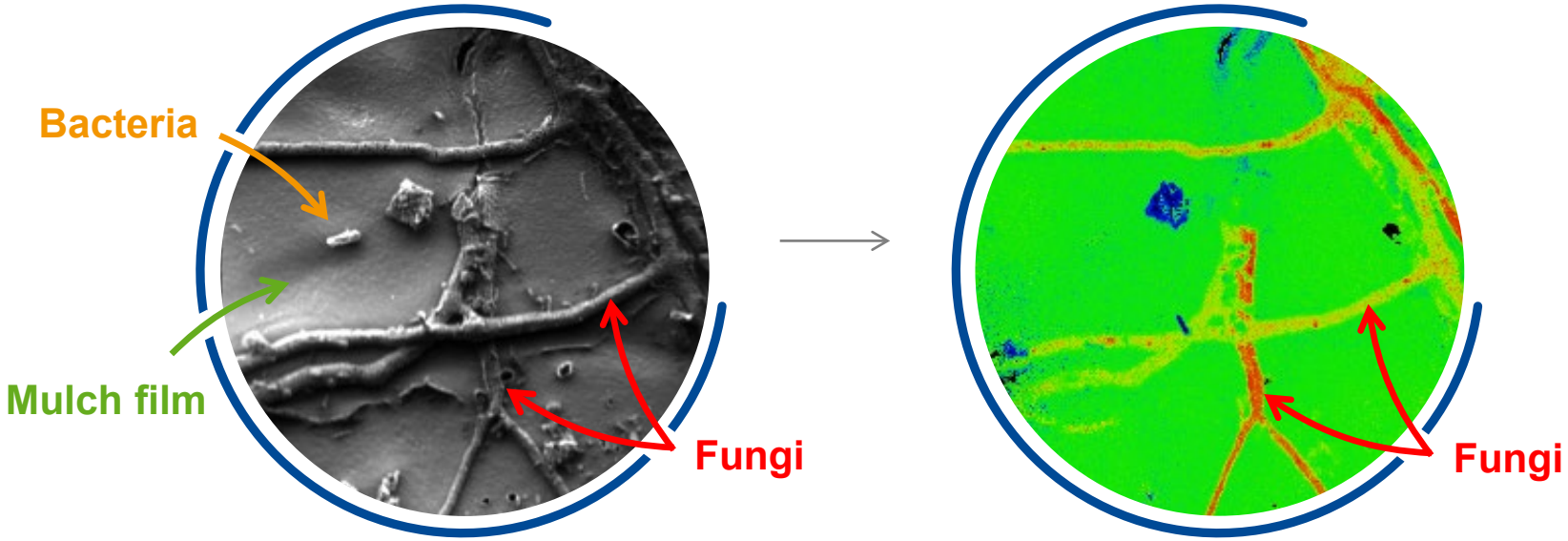
Method toolbox: ^{13}C labelling, CRDS (Cavity Ring Down Spectroscopy), Nano-SIMS (nanoscale secondary ion mass spectrometry), ^{13}C-DNA SIP (DNA - Stable Isotope Probing), soil extraction methods

Conversion into microbial biomass shown by nanoscale secondary ion mass spectrometry (NanoSIMS)

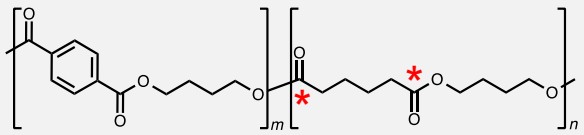


^{13}C atom percent

^{13}C / (^{12}C + ^{13}C) (%)

5
4
3
2
1

Enrichment of labelled polymer derived carbon (red) in fungi



poly(butylene adipate-co-terephthalate)
PBAT: labeled in adipate

Images reprinted with permission of AAAS. From Zumstein et al.,Science Advances 2018;4: eaas9024.

★ Modified ^{13}C labeling of the monomers

ETH zürich

Conversion of PBAT (all monomers) into microbial biomass has been proven.

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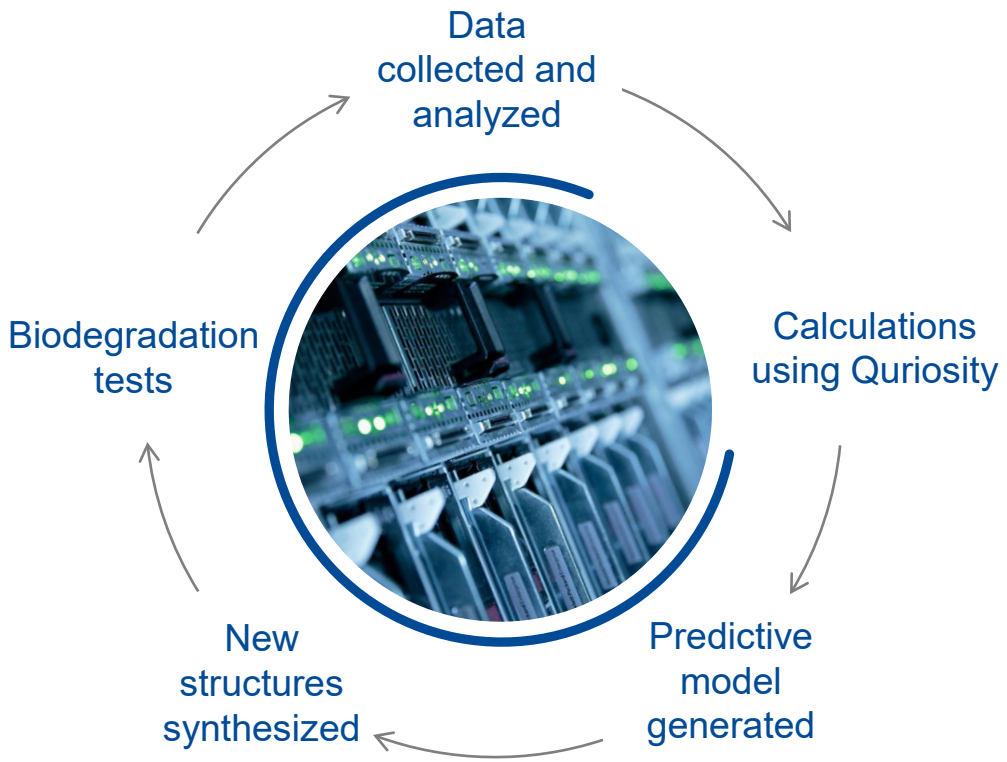
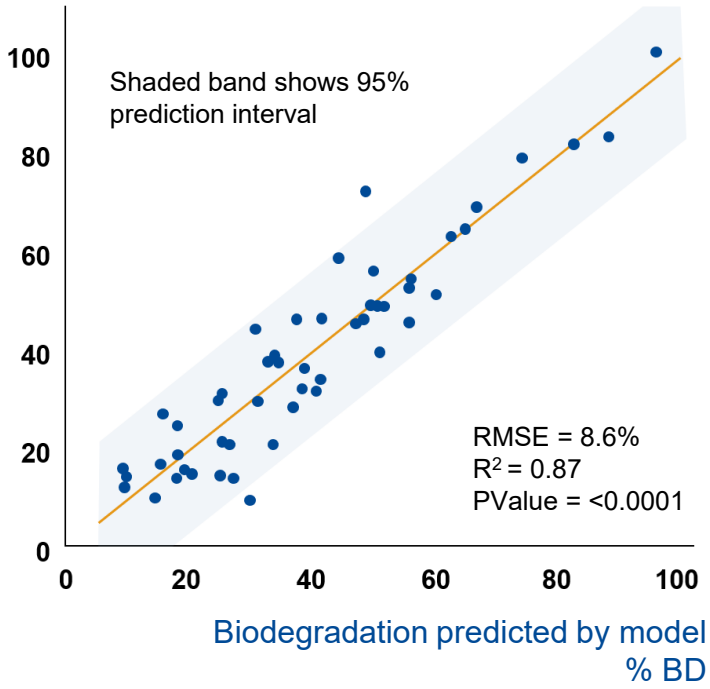
Predictive biodegradation modelling

How is a model developed?



Model correlation with lab tests:

Biodegradation in biotest
%, OECD 301, 28d



A novel machine learning model accurately predicts the biodegradation of polymers in different end-of-life environments.

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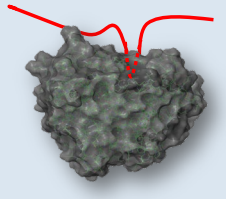

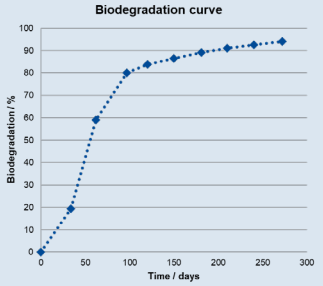

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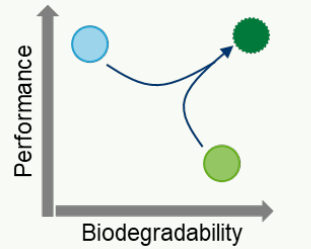

material development and formulation

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Holistic approach for biodegradability with different technologies and partnerships

Lab test systems

60 soils investigated

Correlation & reliability

Mesocosm & field conditions

Field trial in Switzerland

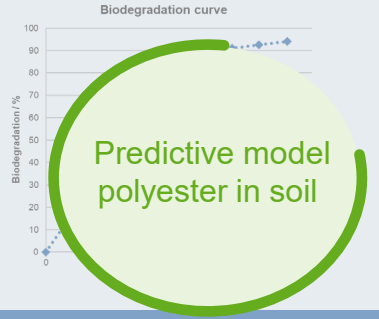
EN 17033

Austria case study constructive dialogue

Cooperations academia & industry

6 publications in high impact journals

derstanding of specific material biodegradation
target end of life environment



Predictive model polyester in soil

Data infrastructure and consistency, automation & predictive modelling

eocio films tested for different crops

material development and formulation

700 microbes indentified

Microbiology & enzymes

Biodegradation pathways / fate of material

Analytical tools for complete biodegradation assessment

CRDS, NanoSIMS, solvent extraction established

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